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Farmers' Perceptions of Climate Change Issues in Tetritskaro Municipality, Georgia

Mariam Elizbarashvili[1,*], Bela Kvirkvelia[1], Nino Chikhradze[1], Daniel Germain[2], Jeremy Pal[3], Tamar Khuntselia[1]

[1] Department of Geography, Faculty of Exact and Natural Sciences, Ivane Javakhishvili Tbilisi State University, Tbilisi, Georgia

[2] Department of Geography, Université du Québec à Montréal, Montreal (Quebec) Canada

[3] Risk Assessment and Adaptation Strategies Division, Euro-Mediterranean Center on Climate Change and Ca' Foscari University, Venice, Italy

HIGHLIGHTS

- Farmers have more or less similar perceptions of extreme weather events in Tetritskaro, Georgia
- Male farmers mostly have information on climate change issues through their fellow farmers
- Female farmers rely on indigenous knowledge of the local environment
- There is a necessity to develop climate change adaptation-intervention policies in Tetritskaro

Abstract

Agriculture is the traditional and leading field of economy of Tetritskaro Municipality, but it faces the challenge of changing climate. The study examines the perceptions of climate change among male and female farmers in Tetritskaro, including their primary sources of information, chosen adaptation measures, and their respective needs. Climate change data that are available in Tetritskaro focused on characteristic extreme weather events coupled with face-to-face interviews from 254 farmers (male - 53%, female - 47%) was analyzed. The study revealed that men and women have more or less similar perceptions of climate change issues. Male farmers primarily rely on conversations with fellow farmers for information on climate, seasonal prediction, and weather forecasts, while female farmers depend on indigenous knowledge of the local environment. Male and female farmers have adapted to the changes in climate similarly by applying some measures, while the exchange of information between fellow farmers, use of various hail protection products, and crop diversification techniques are more frequent among male farmers. Farmers expressed the need for low-interest loans to purchase agricultural products and equipment and restore/create windbreak zones. Most of the male farmers indicate the need for the introduction of new technologies, while female farmers are more in need of training in agricultural activities. The reliance on the experience of other farmers can be seen as a form of social learning and knowledge sharing. Understanding and respecting these local communication channels and sources of knowledge is important for designing effective extension programs and information campaigns. Addressing the traditional men-women roles and cultural and social norms is critical to increasing the adaptation opportunities of female farmers. The study

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Corresponding Author E-mail: mariam.elizbarashvili@tsu.ge

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highlights the necessity of developing climate change adaptation policies and interventions in Tetritskaro. The obtained results can be used in other agricultural regions with the same problems.

Keywords: Agriculture, Farmers' needs, Adaptation, Climate change, Development, Tetritskaro Municipality

1. Introduction

Climate change refers to long-term changes in the Earth's climate, including changes in temperature, precipitation, and weather patterns. These changes are predominantly fueled by human activities, notably industrial processes, fossil fuel combustion, and deforestation, which release greenhouse gases like carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O) into the atmosphere. These gases trap heat, creating a warming effect known as the greenhouse effect. This warming has various impacts, including rising global temperatures, melting ice caps and glaciers, sea level rise, and a rise in the frequency and intensity of extreme weather events (Easterling 2000; Ossó et al. 2022). Climate change, characterized by an increase in the frequency and intensity of extreme weather events, (Harvey et al.2018; Camila et al. 2019; Balasha and Nkulu 2021; Rasul 2021; Karume et al. 2022; Balasha et al. 2023), is believed to directly impact agricultural production and the well-being of populations worldwide (Pangapanga et al. 2012; Chisale 2013; Ofoegbu et al. 2016; Harvey et al. 2018; Missanjo et al. 2019; Camila et al. 2019; Balasha and Nkulu 2021; Rasul 2021; Karume et al. 2022; Balasha et al. 2023). Anticipated future climate change and the impact of extreme weather events on agriculture escalates the need for socially just timely responses, the development and implementation of measures for adaptation, considering the characteristics of different countries, regions, and communities (Monirul Alam et al. 2017; Adger 2001), where the local farmers can make the greatest contribution. Studies have shown that, when farmers perceive climate change and extreme weather impacts on agriculture, they are more involved in the creation and execution of adaptation plans, as well as the support for policies and programs that aim to solve these problems (Niles et al. 2013; Arbuckle et al. 2013; Bollettino et al. 2020; Nnko at al. 2021). Conversely, when farmers do not perceive these impacts, they may develop or implement inappropriate measures that hinder the adaptation process (Taylor et al. 1988). Therefore, knowing how male and female farmers perceive these impacts and what determines their adaptation strategy (Slegers 2008; Bryan et al. 2009; Mertz et al. 2009; Weber 2010; Zampaligré et al. 2014; Chakraborty et al. 2019; Lee et al. 2019; Buylova et al. 2020;.) can allow us to provide farmers with new opportunities for more targeted all farmers-responsive adaptation policies (Amani et al. 2022; Karume et al. 2022) and to design interventions that are more appropriate for the local context (Balasha et al. 2021; Chuma et al. 2022; Karume et al. 2022).

The purpose of this study is to investigate how farmers in Tetritskaro Municipality in the region of Kvemo Kartli, Georgia, perceive climate change and various extreme weather events. More specifically, we seek to know the most significant extreme events (e.g., strong winds, hail, drought, heavy rainfall, and snowstorms) for Tetritskaro and the most damaging for agriculture. In response to the changing climate, we investigated adaptation measures such as the use of various hail protection products, improvement of irrigation systems, sharing information with fellow farmers, changes in crop types and rotations, use of pesticides, use of fertilizers, changes in crop irrigation, and shifts in the growing season (sowing and harvest dates). As part of the analysis, we examined the differences in perceptions and needs between male and female farmers.

The findings from this study will enhance the comprehension of farmers' knowledge, challenges, and practices. This understanding will, in turn, contribute to enhancing adaptation processes and outcomes, leading to improved responses to climate change and weather extremes in Tetritskaro Municipality, where agriculture is the predominant sector.

2. Materials and Methods

2.1 Study area

The research for this study was conducted in Tetritskaro Municipality, which is located in southeastern Georgia in the Kvemo Kartli region, has only 22500 inhabitants, and occupies 520 km^2 (National 2023) (Figure 1). The municipality is a significant agricultural area with farming, playing a crucial role in the local economy

and community livelihoods (Agricultural 2014). Farmers primarily sell their agricultural products both on the local market, in the country's capital, and in nearby Armenia and Azerbaijan (however, the land border with Azerbaijan has been closed in recent years). The municipality of Tetritskaro was selected for this study since agricultural activity is a traditional, leading economic branch of the municipality, on the other hand, the physical-geographical location of the municipality and the difficult terrain determine the peculiarity of temperature and precipitation distribution and the variety of extreme weather events.

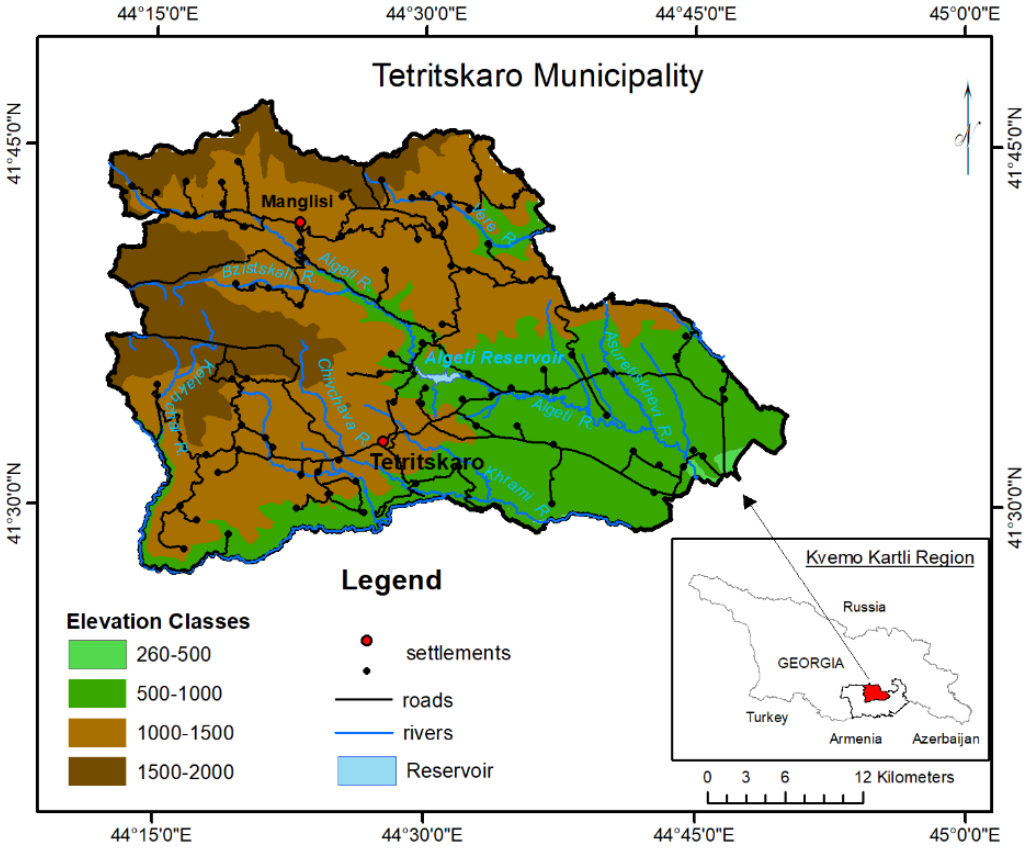

Figure 1. Location of the study area.

The relief of Tetritskaro is characterized by mountainous terrain. A moderately humid climate prevails here with moderately cold winters and long warm summers. Average annual air temperatures in the municipality range from 2 °C in the mountains to 12 °C in the plains (Elizbarashvili 2017). The temperature of the coldest month of the year, January, varies from 0 °C in the lowlands to -11 °C in the mountains, while the temperature of July, the warmest month of the year is 15 °C in the mountains and 25 °C in the lowlands. Average annual precipitations vary from 500 mm in the plains to about 900 mm in the mountains. The maximum precipitations are observed in spring and summer (May 119 mm), and the lowest precipitations – in winter (December 30 mm) (Elizbarashvili 2017; Elizbarashvili et al. 2017).

Air temperatures in Tetritskaro have been increasing by approximately 0.17 °C per decade, precipitation has been decreasing by 5 % per decade over the past several decades (Elizbarashvili et al. 2017).

Strong winds (average > 15 m s-1) and gale-force winds (> 32 m s-1) are the most frequent, long-lasting, and intense events (Elizbarashvili 2017), which can last from several hours to several days. The average number of days with strong winds in the Tetritskaro area is 10. The maximum number of days with strong winds during winter can reach 20. During a strong wind, its highest speed is 28 m s-1in Tetritskaro. However, gale-force winds are also observed in the municipality. Strong winds most often are spread over an area of 500-1000 km^2, its recurrence is 40 %. The recurrence of the occurrence of strong winds in an area of less than 500 km^2 is 25 %, it can also be spread over an area of more than 1000 km^2 (Elizbarashvili 2017). Wind extremes are one of

the major processes and problems in the area affecting soil fertility; they also directly damage and destroy crops, causing significant material losses, according to the Agriculture and Rural Development Strategy of Georgia 2021-2027 and Action Plan 2021-2023 (Agriculture 2022). This study also shows similar results according to farmers; the most characteristic extreme weather events in Tetritskaro Municipality are strong winds, and strong winds have the most negative impact on agricultural activities.

Hail events, associated with convective clouds, typically occur in spring and the first half of summer (Elizbarashvili 2017; Elizbarashvili et al. 2014). In Tetritskaro, the largest number of hailstorm days is 14 days a year. In 38 % of cases hail damages the territory with an area of 1 to 3 square kilometers; in 33 % of cases, it damages an area of less than 1 sq. km. An area of more than 3 sq. km is damaged in about 30 % of cases of hailstorms. Rarely, hailstones damage much larger areas, for example, more than 50 square kilometers are damaged in 3 % of cases (Elizbarashvili et al. 2014).

The duration of hailfall is 9-10 minutes. In 60% of instances, hailfall lasts for less than 5 minutes, while in 80% of cases, it lasts less than 10 minutes, and in 3 % of cases, hailfall can last for an hour and a half (Elizbarashvili et al. 2014).

Fog is observed in all seasons, although it is relatively rare in summer. The average number of foggy days in Tetritskaro is 29 days during the winter, spring, and autumn seasons and can in some years exceed 60 days per season. The number of dangerous fog days, when the visibility area is less than 50 m, varies between 7-25 during the year in Tetritskaro (Elizbarashvili 2017).

The average fog duration is 11 hours, and the duration of strong fog (visibility < 50 m) is also 11 hours. The total duration of fog in the Tetritskaro municipality is greatest in winter with an average duration of 315 hours, 295 hours in fall, 260 hours in spring, and only 56 hours in summer. The areas of fog distribution can be several thousands of square kilometers (Elizbarashvili 2017).

According to some previous assessments (Agriculture 2022), fog events affect yield and cause delays in transporting the crops to the market in the Tetritskaro municipality.

Snowstorms are typical of the mountainous regions of Tetritskaro Municipality. The average annual number of snowstorm days is 4, although the largest number of snowstorm days is 12 days. According to the Tetritskaro weather station, during a blizzard, the wind speed may reach 20 m s-1, but speeds of 6-9 m s-1 are most often observed (Elizbarashvili 2017).

Abundant atmospheric precipitations (when their amount is not less than 30 mm per day) occur in the municipality during the warm period of the year, mostly in May and June. The average amount of abundant precipitations is 35-45 mm, and the average duration is 7-12 hours. Abundant precipitations are not frequent and occur on average 4-5 days during the year, nevertheless, extreme precipitations of significant intensity are possible in individual years (Elizbarashvili 2017). For example, the maximum daily precipitations are recorded in Tetritskaro - more than 100 mm.

Dry days are considered the days when the average daily air temperature is higher than 25 °C, atmospheric precipitations are less than 5 mm and the relative humidity is less than 30 %. According to the Atlas of Natural Hazards and Risks of Georgia (Atlas 2012), a severe drought is observed in Georgia once every 15-20 years, and the trend of increasing the frequency of this event is observed both in the territory of Georgia as a whole and in Kvemo Kartli, although according to the same atlas, the drought danger in Tetritskaro Municipality is not high during the vegetation period.

The simultaneous occurrence of the discussed events in the territory of Tetritskaro Municipality is very rare, although some complexes, containing fog, strong wind, and hail, are relatively frequent (Elizbarashvili 2017).

The agricultural insurance project started in Georgia in 2014. The insurance packages available within the project cover losses caused by extreme weather events (for example, natural disasters: floods, storms, and (in the case of citrus) autumn frosts). However, there is a lack of willingness to participate in insurance programs.

There is no tradition of insurance in the agricultural sector of Georgia since farmers do not have proper knowledge and experience regarding these issues. Consequently, this leads them to refrain from insuring their products. In addition, farmers do not trust insurance companies because they are not entirely sure how the insurance company will react in case of the development of negative events. This ambiguity and lack of trust significantly reduce their willingness to participate in the insurance program.

2.2 Research methods

The Law of Georgia on Employment defines *self-employed: "Self-employed - a person working in his enterprise or farm to earn a profit or income (in money or in-kind)",* according to the Legislative Herald of Georgia. Law of Georgia about employment, Consolidated version (final) (Legislative 2006). According to the Municipal Assessment Report, Tetritskaro (Municipal 2020), there are 263 self-employed farmers, who grow vegetables, fruits, cereals, and other farm crops. We obtained information about these farmers at the municipality's city hall. During the autumn of 2022, the self-employed farmers in Tetritskaro Municipality were interviewed with questionnaires. A total of 254 self-employed farmers from 20 villages were interviewed; 9 farmers refused to participate in the survey or could not be interviewed.

Only self-employed farmers were selected for the research since they are directly responsible for managing agricultural activities and making decisions about the measures required to adjust to climate change and extreme weather events. A face-to-face interview method was used to survey the farmers. Each interview typically lasted between 30 and 40 minutes. We started the survey by introducing ourselves to farmers, explaining the purpose of our study, and offering them to participate in the survey. The questionnaire consisted of closed-ended questions with text-based and yes/no answers, which made it easier for us to collect quantitative data, as well as to categorize and analyze the answers. The face-to-face interviews allowed us to build trust and rapport with farmers, leading to honest and authentic responses, asking follow-up questions, having conversations and discussing their needs, and interests, and clarifying any confusion or misunderstandings.

Information was collected about the age and gender of farmers including the number of years of farming experience they have; how they perceive climate change; extreme weather events; which extreme events are typical for the territory; which extreme weather events have the most negative impact on agricultural activities (together with extreme weather events, we also considered fog, which is characteristic of the territory of the municipality and represents a dangerous weather event); their main sources of information for climate change and extremes as well as for seasonal predictions and weather forecasts; the adaptation measures chosen and implemented in response to climate change and extremes.

For statistical analysis of the survey, the collected information was coded as SPSS data (Landau and Everitt 2004) and then cleaned and processed during February 2023. Descriptive statistics − frequencies, means, and percentages were employed for the data analysis. A chi-square test was used to assess whether any observed differences in perception between male and female farmers are statistically significant, or if they could have occurred by chance. The test involves calculating the chi-square statistics, which measures the difference between the observed and expected frequencies, standardized by the expected frequencies. The calculated chi-square value is then compared to a critical value from the chi-square distribution, based on the degrees of freedom and the selected significance level (usually 0.05). If the chi-square value calculated exceeds the critical value, the null hypothesis (no association between gender and perception) is rejected, indicating a significant association between the two variables.

In the article, tables and graphs are constructed according to the percentage of male farmers and female farmers who answer the following in the survey: 1) **average annual air temperature in the territory of Tetritskaro Municipality:** 1. Increasing; 2. Decreasing; 3. Unchanged; 4. Do not know; 2) **Annual amount of precipitation in the territory of Tetritskaro Municipality:** 1. Increasing; 2. Decreasing 3. Unchanged, 4. Do not know; **3) Which of the following extreme weather events is the most typical for the territory of Tetritskaro Municipality?** 1. Hail, 2. Heavy rainfall, 3. Snowstorm, 4. Strong wind, 5. Drought, 6. Fog; 4) **Climate change and extreme weather events have had a negative impact on agricultural activities:** 1. Yes, 2.

No, 3. Do not know; **5) Which of the following extreme weather events has the most significant negative impact on agricultural activities in the territory of Tetritskaro Municipality?** 1. Hail; 2. Heavy rainfall; 3. Snowstorm; 4. Strong wind; 5. Drought; 6. Fog; **6) What is the main source of information about climate change, and extreme weather events?** 1. Television; 2. Internet; 3. Own observation (indigenous knowledge of the local environment); 4. Conversations/information exchange with other farmers **7) Have you carried out any of the adaptation measures listed below?** 1 - Yes 2 – No

1. Crop diversification,
2. Improvement of irrigation systems,
3. Use of pesticides,
4. Use of fertilizers,
5. Watering crops,
6. Early harvest,
7. sharing information,
8. Early sowing,
9. Use of hail protection products.

This study was approved by the Ethics Committee at the Faculty of Exact and Natural Sciences (TSU) № FR1914993-09-03-20. Informed consent was obtained from all participants and the study complies with all ethical regulations.

3. Results and Discussion

53 % of the farmers participating in the study identified as male and 47 % as female. The average age of all participants was 54 with an average of 20 years of farming experience; the average age of male and female farmers was 53 and 55 years, respectively, each with an average of 22 and 18 years of farming experience.

3.1 Sex disaggregated dimensions of farmers' perceptions of climate change and extreme weather events

Most of the male and female farmers believe that the average annual temperature is increasing, and the average annual rainfall is decreasing in Tetritskaro Municipality, Georgia (Table 1). A chi-square test (> 0.05) showed that male and female farmers perceive the trend of changes in air temperature and atmospheric precipitation in the same way.

Table 1. Perceptions of climate change parameters in Tetritskaro Municipality.

№	Farmers		Average annual precipitation	Average annual temperature
1	Male %	Increasing	0.0	82.2
	Female %		0.0	85.7
2	Male %	Decreasing	91.9	0.0
	Female %		89.9	0.0
3	Male %	Unchanged	5.2	9.6
	Female %		6.7	9.2
4	Male %	Do not know	3.0	8.1
	Female %		3.4	5.0

87% of farmers surveyed in Tetritskaro Municipality (88.9% of male farmers and 84.9% of female farmers) believe that climate change and extreme weather events have negatively affected agricultural activities. A lower percentage of both male and female farmers think that these events do not impact agricultural activities or are uncertain (Table 2). No statistically significant difference exists between the opinions of male and female farmers at the 5% level.

The impacts of climate change and extreme weather events on agriculture are complex and influenced by factors such as the region, type of crop, and farming practices. Severe weather events like strong winds, hail, and storms can destroy crops or significantly reduce their yields, leading to income loss for farmers and food insecurity for the population. Climate change can also diminish soil fertility, as higher temperatures, altered

rainfall patterns, and other factors change soil composition and quality. This can make crop cultivation more challenging, requiring farmers to invest more resources to maintain soil health. Furthermore, extreme weather can disrupt transportation networks, hindering farmers' ability to deliver their crops to market on time. The presence of dense fog on roads, for example, can cause significant delays in crop transportation, leading to financial losses for farmers and shortages of food for consumers (Harvey et al. 2018; Camila et al. 2019; Balasha and Nkulu 2021; Rasul 2021; Karume et al. 2022; Balasha et al. 2023).

Table 2. Farmers' perceptions of the negative impact of climate change and extreme weather events on agricultural activities in Tetritskaro Municipality.

№		Farmers	Agricultural activities have been adversely affected by climate change and extreme weather events.
1	Agree	Male %	88.9
		Female %	84.9
2	Disagree	Male %	5.2
		Female %	6.7
3	Do not Know	Male %	5.9
		Female %	8.4

When evaluating the effects of climate change and extreme weather events in Tetritskaro Municipality, farmers considered crop destruction, decreased soil fertility, and delays in delivering crops to the market caused by frequent and dense fog on the roads.

According to farmers, the most characteristic extreme weather events in Tetritskaro Municipality are strong winds, hail, and such dangerous events as fog, and they also believe that strong winds, hail, and fog have the most negative impact on agricultural activities. Indeed, 31.9% of male farmers and 34.5% of female farmers consider strong winds to be the most typical extreme weather event, while the majority of male (37.8%) and female (38.7%) farmers believe that strong winds have the most significant negative impact on agricultural activities. Additionally, 31.1% of male and 30.3% of female farmers see hail as the most typical extreme weather event, with 31.9% of male and 35.3% of female farmers attributing the most significant damage to agricultural activities to hail. Furthermore, 28.9% of male and 27.7% of female farmers view fog as the most typical extreme weather event in Tetritskaro Municipality, while 19.3% of male and 10.1% of female farmers believe that fog has the most significant negative impact on agricultural activity (Figure 2).

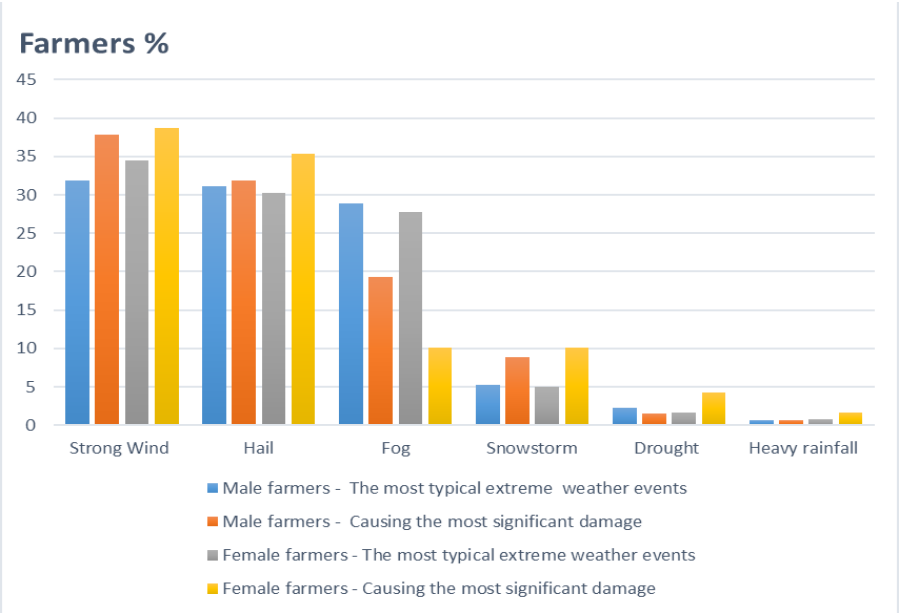

Figure 2. The most typical extreme weather events and extreme weather events cause the most significant damage to agricultural activities in Tetritskaro Municipality.

Far fewer farmers named snowstorms, drought, and heavy rainfall as the most characteristic extreme weather events, and accordingly, far fewer farmers believe that snowstorms, drought, and heavy rainfall have the most negative impact on agricultural activity in Tetritskaro Municipality (Figure 3).

There is no statistically significant difference between the opinions of male and female farmers, except regarding the most significant negative impact on agricultural activity, specifically in the case of fog. This difference may be attributed to local peculiarities and the impact of fog on roads, which will be discussed below.

3.2 Sources of information about climate change, seasonal predictions, and weather forecasts

Farmers relied on various sources of information for updates on climate change, seasonal predictions, and weather forecasts.

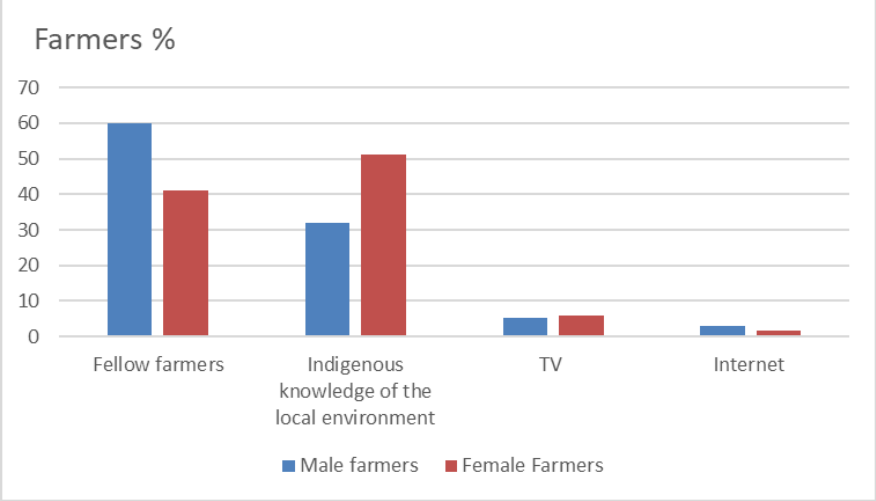

Figure 3. The main sources of information about climate change, seasonal predictions, and weather forecasts among male and female farmers in Tetritskaro Municipality.

Most male farmers (60%) cited conversations with other farmers as their primary source of information on climate change, seasonal predictions, and weather forecasts (Figure 3). On the other hand, the majority of female farmers (51.3%) mentioned indigenous knowledge of the local environment as their main source, such as personal observations of the sky, clouds, and birds, which provide insights into expected weather patterns.

It is important to state while conversations can include the sharing of indigenous knowledge, the two concepts are not interchangeable. Indigenous knowledge is a specific body of knowledge developed by people, often passed down orally from generation to generation. Whereas conversations can involve any type of communication between individuals or groups, indigenous knowledge is not solely based on farmer-to-farmer sharing. Indigenous knowledge is also shaped by a wide range of cultural and environmental factors, including spiritual beliefs, social customs, and historical experiences. It reflects a deep understanding of the relationships between humans and the natural world and is often rooted in local ecosystems and landscapes (Magni 2017).

Only a few male and female farmers rely on the Internet and television for information about climate change, extreme events, seasonal predictions, and weather forecasts. A chi-square test (<0.05) indicated that the primary source of information differs between male and female farmers.

The difference in the main source of information between male and female farmers can be caused by cultural norms, social networks, and communication patterns. Men have a wider circle of friends and get information from them, while women hang around in a narrower circle and therefore, prefer their own observations and indigenous knowledge.

3.3 Male and Female farmers and adaptation practices

We examined the adaptation measures employed by male and female farmers in response to climate change and extreme weather events in Tetritskaro Municipality (Table 3). A notable difference was found in the adoption of several adaptation strategies. Crop diversification is more prevalent among male farmers than female farmers. Male farmers also engage more in information sharing, discussing topics like soil fertility, weather conditions, and agricultural product prices. They are more active in improving irrigation systems and using various hail protection products. However, there were no substantial differences between female and male farmers in the use of some adaptation strategies, such as shifting cropping seasons (sowing and harvest dates), pesticide and fertilizer application, and crop irrigation.

Table 3. Adaptation practices of male and female farmers to climate change and extreme weather events in Tetritskaro Municipality

№	Practices	Male (%)		Female (%)		Pearson Chi-Square
		Yes	No	Yes	No	
1	Crop diversification	88.1	11.9	69.7	30.3	0
2	Improvement of irrigation Systems	14.8	85.2	5	95	0.010
3	Use of pesticides	72.6	27.4	74.8	25.2	0.692
4	Use of fertilizer	77.8	22.2	79.8	20.2	0.690
5	Watering crops	88.9	11.1	91.6	8.4	0.470
6	Early harvest	51.1	48.9	47.1	52.9	0.519
7	Sharing information	62.2	37.8	47.9	52.1	0.022
8	Early sowing	48.1	51.9	54.6	45.4	0.303
9	Use of various hail protection products	53.3	46.7	10.1	89.9	0

3.4 Discussion

3.4.1 Sex disaggregated dimensions of farmers' perception of climate change and extreme weather events in Tetritskaro Municipality

According to the study (Elizbarashvili 2017), average annual air temperatures have been increasing and average annual precipitations have been decreasing in Tetritskaro over the last few decades. Both male and female farmers adequately perceive these changes in climatic parameters, in particular, the trend of decreasing average annual precipitation and increasing average annual air temperatures. The finding that none of the respondents mentioned an increase in precipitation and a decrease in temperature suggests a high level of awareness and observation among the farming community in Tetritskaro.

Several factors could explain why farmers in Tetritskaro municipality can adequately perceive these changes: farmers are often highly attuned to changes in weather patterns and climatic conditions due to their daily interaction with the environment; they may notice changes in rainfall patterns, temperature fluctuations, and other climatic indicators through their farming activities and observations of the natural world; changes in precipitation and temperature can directly affect agricultural productivity and livelihoods. Farmers may be more likely to notice these changes because they have a direct impact on their crops, water availability, and farming practices.

According to Figure 3, in Tetritskaro Municipality, the majority of male farmers name fellow farmers as the main source of information about climate change, seasonal predictions, and weather forecasts, while the majority of female farmers name indigenous knowledge of the local environment as the main source of information. Local and traditional knowledge systems often include observations and practices related to weather and climate. Farmers draw on this knowledge, which has been passed down through generations, to understand and interpret changes in climatic parameters; farmers often rely on information and observations shared within their community networks. Discussions with other farmers, local leaders, and community members can help reinforce awareness of climate change and its impacts.

Farmers perceive and state that strong wind, hail, and fog are the most typical for the municipality, which also corresponds to the data in the previously published literature (Elizbarashvili 2017). Farmers' belief that climate change and extreme weather events adversely affect agricultural activities aligns with current research on global climate change, highlighting its widespread impact on agriculture (Camila et al. 2019; Balasha and Nkulu 2021; Rasul 2021; Karume et al. 2022). Male and female farmers perceive that strong winds, hail, and fog have the most significant negative impact on agricultural activities. Farmers talk about crop destruction, reduced soil fertility, delays in the delivery of crops to the market, and the occurrence of pests. According to historical data, wind erosion is one of the biggest problems affecting soil fertility in Tetritskaro Municipality, according to the Agriculture and Rural Development Strategy of Georgia 2021-2027 and Action Plan 2021-2023 (Agriculture 2022). Strong winds and hail negatively impact agricultural production and yields in the municipality, leading to crop destruction and substantial material losses. (Wheatley 2005; Elizbarashvili 2017).

To address wind extremes and their impacts on soil fertility and crop damage, several precautions can be taken: first, planting trees, shrubs, or other vegetation as windbreaks can help reduce wind speed and protect crops from damage; planting cover crops can aid in shielding the soil from erosion and improve soil fertility, which can be particularly important in areas prone to wind extremes. Increasing soil organic matter through practices such as composting and mulching can help improve soil structure and fertility, making it more resilient to wind erosion; implementing erosion control measures, such as terracing or contour plowing, can help reduce soil erosion caused by wind; planting a variety of crops can aid in mitigating the risk of complete crop failure due to wind damage, as different crops may be more or less susceptible to damage; keeping track of weather forecasts and conditions can help farmers take preventive measures, such as harvesting crops early or securing loose items that could be damaged by the wind; building infrastructure, such as wind-resistant storage facilities or greenhouses, can help protect crops and other assets from wind damage.

Implementing agricultural insurance schemes and risk management strategies can help farmers recover from losses due to extreme weather events.

Farmers should also be aware of practices they should not do, such as overexploiting natural resources, which can further exacerbate environmental degradation and climate change. Additionally, farmers should avoid practices that contribute to greenhouse gas emissions, such as burning crop residues, as this can worsen climate change conditions.

The notable disparity between male and female farmers on fog could be due to local peculiarities. Farmers use the crop both for self-consumption and for sale; during the delivery to the market, fog causes visibility problems on roads and delays traffic. In the region, men primarily drive cars and farm vehicles; therefore, delays caused by fog on the roads are more important for them. In addition, it is important that despite the roadwork carried out in recent years, many highways are in unsatisfactory condition, which, together with extreme events, is an added obstacle to the delivery of agricultural products to the market. Therefore, from this point of view, it is necessary to thoroughly maintain the existing roads in the region.

3.4.2 Sources of information about climate change, seasonal predictions, and weather forecasts

In Tetritskaro Municipality, most male farmers cite other farmers as their primary source of information, whereas most female farmers cite indigenous knowledge of the local environment. Indigenous knowledge is holistic, encompassing not just facts about the environment but also spiritual and cultural aspects. It often includes practices and techniques for sustainable resource management, such as farming, hunting, and medicine-making, which have been developed and refined over centuries of living closely with nature. In the context of climate research, indigenous knowledge of the local environment can be valuable for understanding historical climate patterns, changes in the environment over time, and the impacts of climate change on local ecosystems and communities. Like in Tetritskaro Municipality, farmers in various regions of the world rely on indigenous knowledge of the local environment for weather forecasts and seasonal predictions. However, this valuable knowledge is diminishing globally and is gradually disappearing everywhere (Kolawole et al. 2014; Tume et al. 2019; Radeny et al. 2019; Balasha et al. 2023). Recognizing the importance of indigenous knowledge, it is crucial to support its preservation, transmission, and integration into science and policy-making to enhance climate change adaptation efforts (Magni 2017).

The destruction of crops and income loss caused by climate change and extreme weather events compel farmers to seek new information about weather, climate, and their effects on agricultural practices (Belay et al. 2017). Like other regions of the world, in Tetritskaro Municipality, it is important to share this experience and knowledge among farmers (Balasha et al. 2023). At this time, young are benefiting from the expertise of seasoned farmers, who provide them with valuable information on new crop varieties and practices that are more suited to changing weather patterns. It should be noted that very few farmers receive information through television and the Internet, and they trust the experience of other farmers in the area more than the information they find elsewhere.

Research conducted in other regions of the world has shown that low levels of education and a lack of language skills (Tume et al. 2019; Balasha et al. 2023) are the main factors preventing people from using television and the internet as their primary sources of information. In these countries, weather and climate information on the internet and media is mostly provided in foreign languages such as English and French, rather than in the local language (Balasha et al. 2023), this is not the case in Tetritskaro Municipality. Information about the weather in Georgia is available in the Georgian language on the internet and television. In Tetritskaro Municipality, like many rural areas, there is a strong sense of community and mutual support, which is why very few farmers receive information through television and the Internet. Farmers perceive information from other farmers as more relevant and reliable than information from television or the internet, which may not always be tailored to their specific needs and circumstances. Farmers value the opinions and experiences of their peers over information from external sources. Farmers often trust the knowledge and experience of other farmers in their community, because local farmers understand the area's specific challenges and conditions and can provide practical and context-specific advice. Face-to-face interactions with other farmers provide an opportunity for more personalized and interactive communication, where farmers can ask questions, share experiences, and receive immediate feedback.

The joint use of local and scientific knowledge by farmers is important for adaptation to environmental challenges, and the need to take it into account has been noted in many international studies (Kolawole et al. 2014; Tume et al. 2019; Hosen et al. 2020). Thus, conducting workshops that involve farmers in Tetritskaro Municipality could enable them to integrate local knowledge with scientific information, thereby enhancing their agricultural practices.

3.4.3 Male and female farmers and adaptation strategies in Tetritskaro Municipality

Some studies focused on regions outside of Georgia suggest that the main pesticide users are male farmers (Kishor 2007; Kawarazuka et al. 2020; Ali et al. 2020), while others suggest the contrary (Balasha et al. 2023). In Tetritskaro Municipality, female and male farmers similarly use adaptation measures, such as pesticides, fertilizer, watering crops, early sowing, and early harvest. A notable difference exists among male and female farmers in several adaptation strategies in Tetritskaro Municipality, Georgia. There is a more frequent exchange of information among male farmers, and a higher use of crop diversification techniques, hail protection products, and improved irrigation systems among male farmers. Improved irrigation systems and hail protection products require financial resources and physical effort. We got the result that corresponds to several studies in different regions of the world indicating that female farmers are less adaptable due to limited resources and financial capabilities (Fisher et al. 2015; Jost et al. 2016; Doss et al. 2018; Shahla et al. 2019). The reason for the low adaptation rate of female farmers may be due to the social norms and roles in rural communities (Jost et al. 2016), which is similar to our findings. For example, in Tetritskaro Municipality, Georgia, like in many rural communities worldwide, traditional men-women roles, as well as cultural and social norms, dictate that women should primarily be responsible for domestic duties, while men take care of farming activities, women also often have limited mobility. These men-women roles and societal norms may restrict women's access to essential resources, education, and training needed for agricultural adaptation. This can also make it challenging for them to access markets to sell their products (Udry 1996).

The discussion with farmers in Tetritskaro Municipality showed that women and men farmers have a common interest, specifically, the restoration and creation of windbreaks, which cannot be done by individual farmers, and organized action is necessary to attract and unite resources. Also, both male and female farmers

need relatively low-interest loans to purchase agricultural products and equipment, such as pesticides, fertilizer, seeds, various anti-hail equipment, tractors, etc. However, it was revealed that most of the male farmers are interested in introducing new technologies, while female farmers are more in need of training and information in agricultural activities, such as, how to increase soil fertility.

4. Conclusions

In this study, we focused solely on the climatic characteristics of extreme events specific to the region, without considering changes and trends over time in their frequency and intensity. For future research, in addition to the farmer surveys, it is essential to analyze the dynamics of current and future changes in extreme events using large-scale meteorological observations and downscaling techniques, such as regional climate models. This approach will provide detailed information on local climate change trends and extreme weather events. Many studies have used farmer interviews and field observations to assess climate change impacts, primarily focusing on changes in mean annual or seasonal air temperatures and precipitation, as well as adaptation strategies in various landscapes worldwide (Harvey et al. 2014; Belay et al. 2017; Asrat and Simane 2018). However, these studies often highlight a lack of sufficient knowledge regarding the effectiveness and economic aspects of adaptation strategies implemented by farmers. Therefore, future research should aim to conduct more specific studies on each adaptation strategy to enhance our understanding and inform effective decision-making (Balasha et al. 2023).

We consider it interesting to investigate the effectiveness of adaptation strategies in different landscape types not only regarding changes in mean annual or seasonal air temperatures and precipitation but also regarding various extreme weather events since they can have the most negative impact on agriculture. Therefore, for different farm crops, it is necessary to understand these impacts, how they affect yield and profit, and strategies to adapt to them.

The results of this study show that both male and female farmers' perceptions of climate change and extreme weather events align with prior research, which indicates a rise in average annual air temperature and a decline in annual precipitation in Tetritskaro Municipality (Elizbarashvili 2017). They consider strong wind, fog, and hail as the most relevant extreme weather events and consider strong winds and hail to have the most negative impact on agricultural activities. The difference among the male and female farmers was observed only in the case of fog; a greater percentage of male farmers believe that fog has the most negative impact, which can be explained by the fact that more men in the region drive cars and are therefore more likely to be subjected to visibility issues when they deliver their agricultural products to the market.

The primary source of information on climate change, seasonal predictions, and weather forecasts for male farmers is conversations with fellow farmers and local knowledge of the local environment for female farmers. Very few farmers use the internet and television as their main source of information, which can be explained by the fact that farmers more trust their fellow farmers than the information they get from television or the internet. The reliance on the experience of other farmers in the area can be seen as a form of social learning and knowledge sharing that is deeply embedded in rural communities. Understanding and respecting these local communication channels and sources of knowledge is important for designing effective extension programs and information campaigns in rural areas.

It can be concluded that there are significant opportunities for adaptation and enhancing the resilience of the farming community to climate change and extreme weather events in Tetritskaro Municipality. The conditions for further development and modernization of agriculture are very favorable in terms of farmer readiness. Indeed, the farmers are already taking part in adaptation measures to reduce climate-related exposure including extreme weather events.

Male farmers are more inclined to employ various adaptation strategies compared to their female counterparts. This difference can be explained by social norms and roles, resources and financial opportunities in rural communities, as well as adaptation strategy specifics. Thus, addressing these social norms and roles

is critical to promoting equity between males and females in agriculture and increasing the adaptation rate of female farmers in other rural communities of Georgia as well.

Discussions with farmers also showed that most male farmers are interested in introducing new technologies, while female farmers are more in need of training in agricultural activities in connection with climate change; both male and female farmers share an interest in restoring and establishing windbreaks., which cannot be done by individual farmers and require organized action and scientific knowledge. Relatively low-interest loans for purchasing agricultural products and equipment are important for both male and female farmers. By taking into account the needs and interests of male and female farmers, interventions can be designed to build the resilience of the community more effectively and sustainably. Therefore, the role of the local, regional, and national governments may be important by promoting the introduction and implementation of various projects or measures, e.g., such as providing affordable loans, distribution of informative agricultural booklets, training, education activities, etc.

Overall, in rural communities, it is critical to address the traditional men-women roles, and cultural and social norms that are typical not only in Tetritskaro Municipality but also in other regions in Georgia to promote equity between males and females in agriculture and increase the adaptation opportunities of female farmers.

The research highlights the importance of developing climate change adaptation policies and empowering female farmers by granting them access to information, resources, training, and involvement in decision-making processes. This need extends beyond Tetritskaro Municipality to other regions of Georgia.

The findings could inform the development of climate change adaptation policies and interventions that consider the distinct needs and interests of male and female farmers. The results can contribute to enhancing the resilience of the farming community.

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